CHAPTER 1

INTRODUCTION

1.1 General Background

Metal cutting, one of man's oldest manufacturing processes assumes a significant role in today's productivity scenario. This is due to the significant advancement in both machine tools and cutting tool materials. In term of manufacturing efficiency the two are inseparable. Advances in technology in one area require that corresponding technical advances be made in the other. In term of the cutting tool itself, development of more wear resistant tool materials for application in high speed machining has a profound impact on productivity [1].

Productivity, expressed in terms of how fast metal can be removed in machining operations, whether it be turning, milling, grooving, etc, is dependent on the availability of tool materials which can withstand the high temperatures and stresses generated in these operations without undergoing degradation or change in shape. Cutting tools are thus the critical link between raw material and the finish product. The rates determining factor in the chip making process is the cutting tool material itself and to achieve high productivity a tool material must be able to cut at high speed.

The ceramic cutting tool represents different class of cutting tool material with unique chemical and mechanical properties. Thus, there may be a tendency to avoid the use of ceramic tools where they may be applied advantageously. In order to realize the full potential of ceramics, it is essential to have a clear understanding of all variables, which affect the performance of these tools.

This project is undertaken with the aims in understanding the development of ceramic cutting insert of Aluminum Oxide (Al_2O_3) and Titanium Carbide (TiC) for machining steel using vacuum sintering process. The evaluated responses were shrinkage, hardness, density, surface roughness and tool life.

1.2 Problem Statement

Ceramics and ceramic composites remain an attractive candidate materials for cutting tool because of their high resistance to wear and high temperatures. Development of cutting inserts in advanced countries have been established long ago, however in Malaysia the development have been hindered by various reasons such as limited know how, expertise and technologies. This project is undertaken to develop ceramic inserts of Al_2O_3 with addition of TiC particles using vacuum sintering processes. Various combination of composition between Al_2O_3 and TiC was investigated and its effect on the various responses were evaluated. The responses evaluated were densification, surface roughness, shrinkage and machining performance. It is hope that the results of this study will further enhance the knowledge and expertise in the development cutting inserts.

1.2.1 Mechanical Properties

Naturally occurring inorganic substances are heat-treated after adjustment of the grain size and moisture, and some of them are completely molten to be formed into ceramics, while others are formed, heat-treated and made into the ceramic products in the sintered state immediately before being molten. The former product formed in the molten state is known as glass, and the latter product finished in the sintered state includes pottery, refractories, sanitary ware, tiles and cement. These ceramics are called traditional ceramics. By contrast, extremely fine particles of high-purity inorganic substances such as alumina (Al_2O_3), Silica (SiO_3), zirconia's (ZrO_3 and silicon nitride (Si_2N_3) are sintered at a high temperature and made into ceramics; they are called advanced ceramics. These advanced ceramics are used in electronic parts and mechanical parts.

Compared to metals, ceramics have the following relative characteristics: brittleness; high strength and hardness at elevated temperatures; high elastic modulus; and low toughness, density, thermal expansion, and thermal and electrical conductivity [2]. However, because of the wide variety of ceramics material composition and grain sizes, the mechanical and physical properties of ceramics vary significantly.

Because of their sensitivity to flaws, defects, and surface or internal cracks, the presence of different types and level of impurities and different methods of manufacturing, ceramics can have a wide range of properties.

1.3 Objective

Three specific objectives have been defined to simplify the main objective of the project. They were:

1. To develop and fabricate ceramic inserts of Al_2O_3 with TiC using vacuum sintering process.
2. To evaluate the effect of TiC content on the various responses such as densification, surface roughness, shrinkage, hardness and machining performance
3. To evaluate the machining performance of the fabricate inserts with respect of tool life when turning steel.

1.4 Scope of the Project

The scopes of the project were as follows:

1. Vacuum sintering process was employed in producing the ceramic inserts.
2. The material used for the compaction and sintering process was a combination of Aluminum Oxide (Al_2O_3) and Titanium Carbide (TiC)
3. Input parameters used included pressing pressure, pressing time, and sintering temperature.
4. Evaluation on the machining performance was done on turning of steel material.